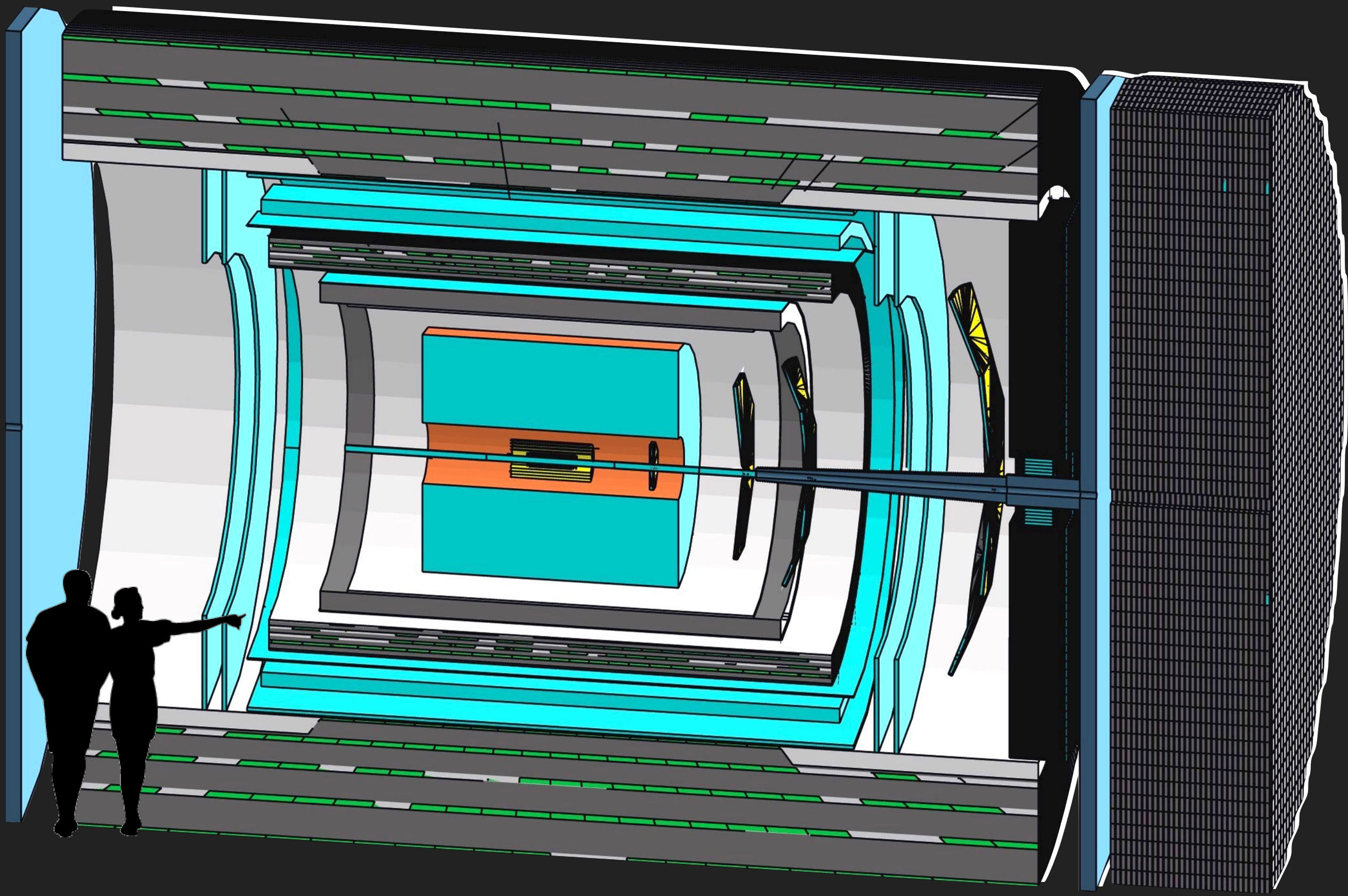
SPHENIX WITH FORWARD INSTRUMENTATION AT RHIC: WHAT CAN WE LEARN WITH IT?

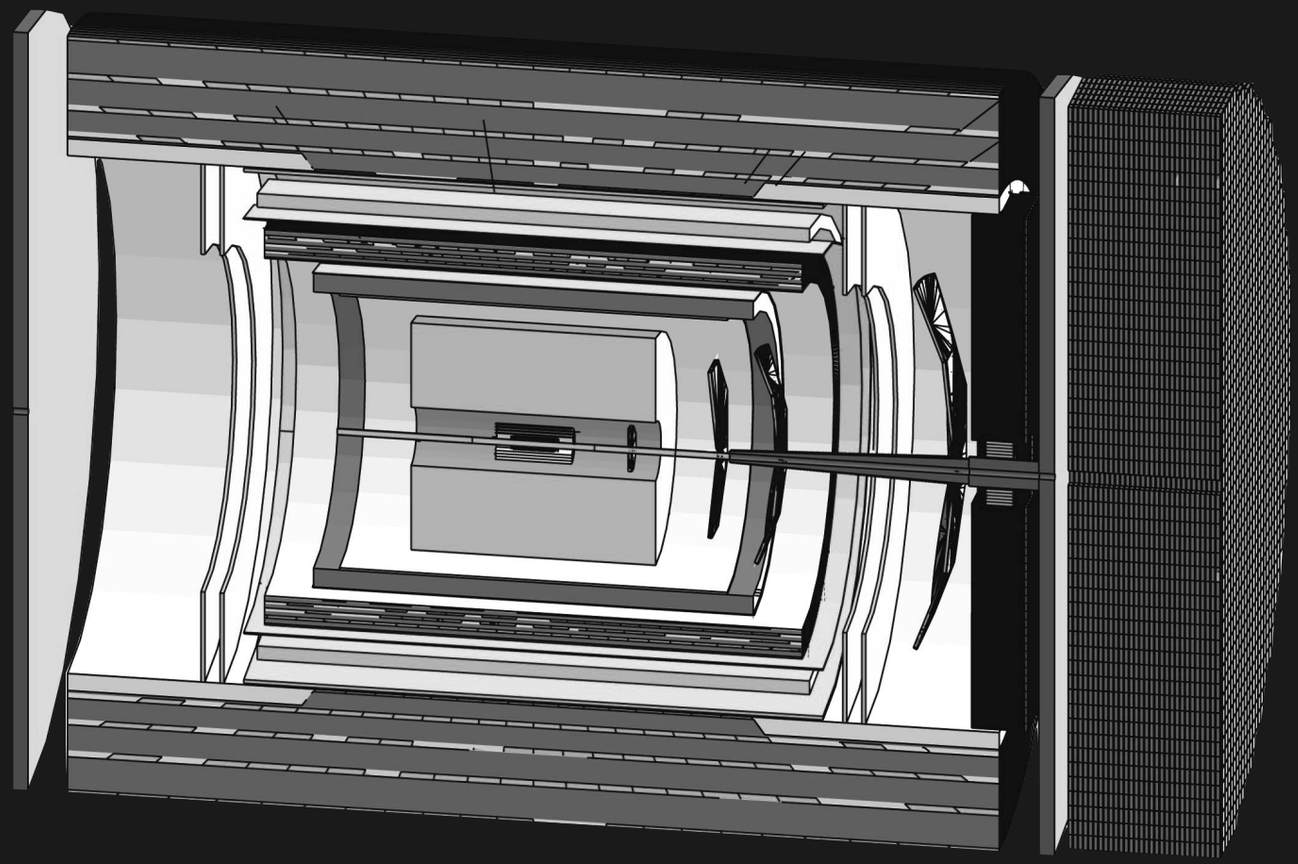
NILS FEEGE

for the sPHENIX Collaboration

RBRC Workshop: Synergies of pp and pA Collisions with an Electron-Ion Collider

Brookhaven National Laboratory, June 26 - June 28 2017

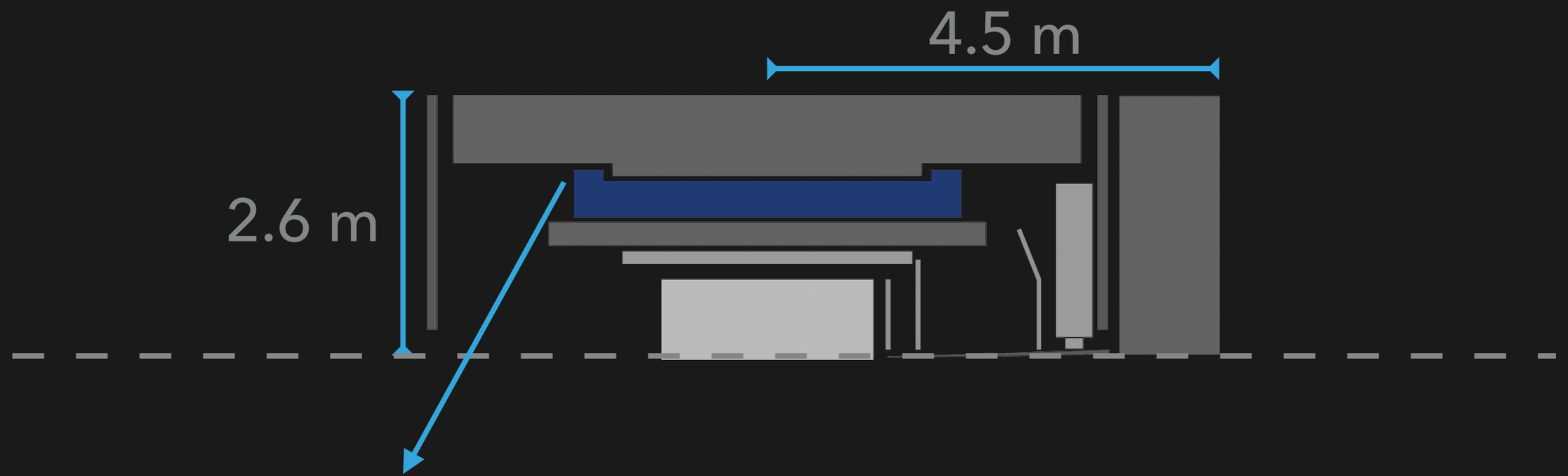




- The sPHENIX experiment (with forward instrumentation).
- Forward Drell-Yan dielectrons: Study how the binding of nucleons into nuclei affects the sea.
- Transverse single-spin asymmetries for jets and dijets: Study parton polarization dynamics and search for non-Abelian effects.

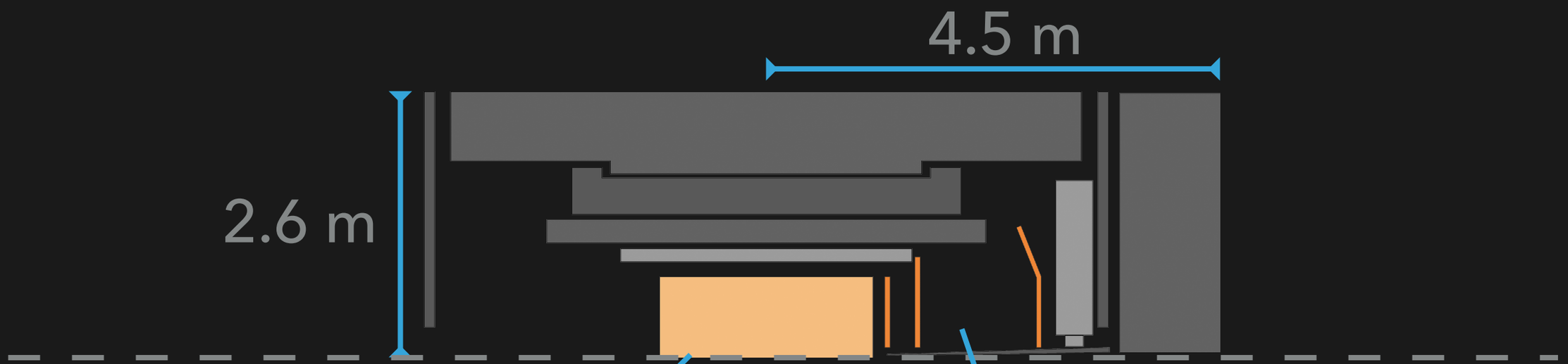
THE EXPERIMENT

MAGNET

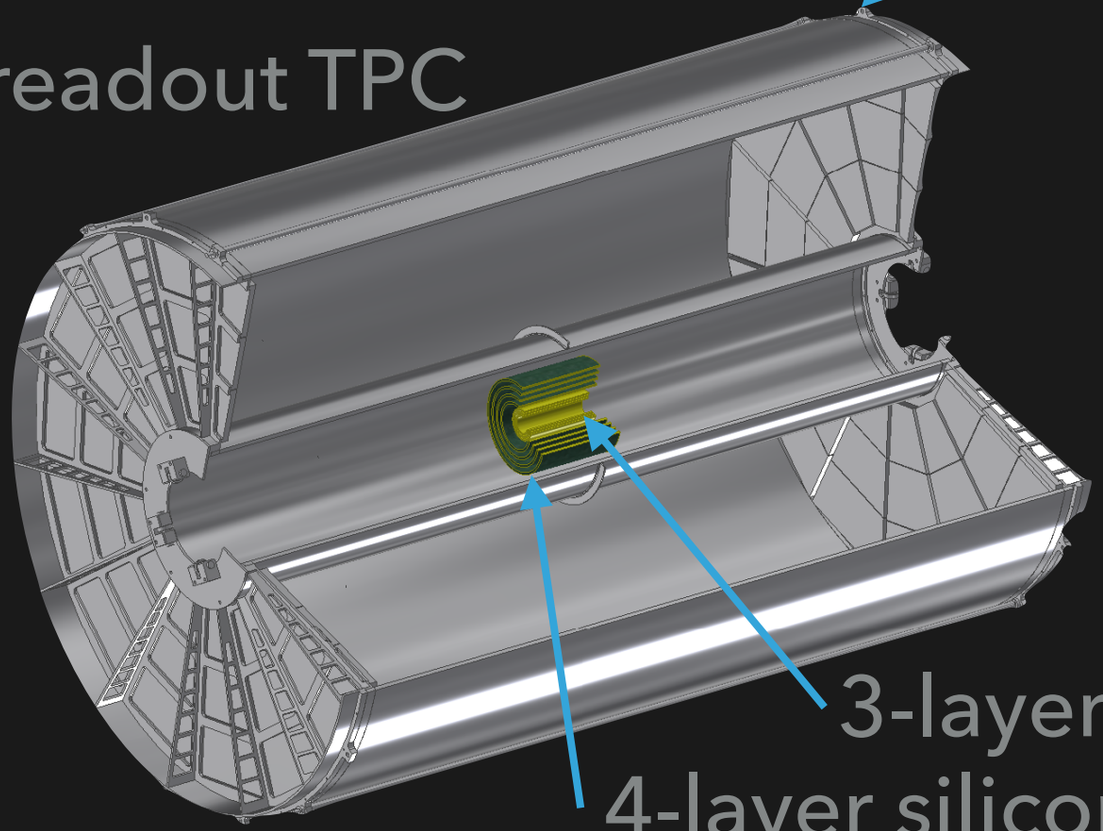


‘BaBar’ Solenoid

TRACKING SYSTEM



Continuous readout TPC

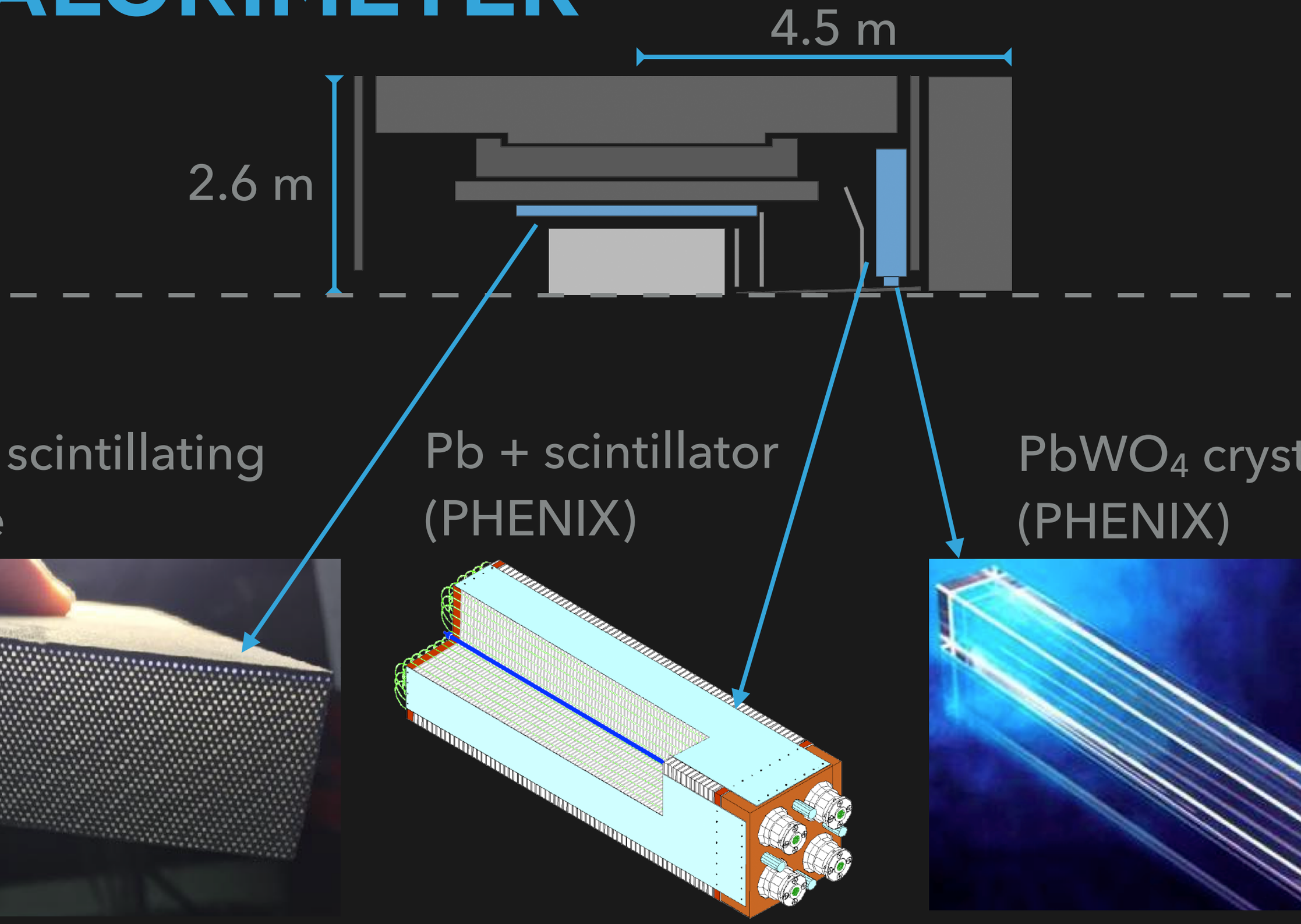


GEM stations

3-layer MAPS vertex detector

4-layer silicon-strip intermediate tracker

ELECTROMAGNETIC CALORIMETER

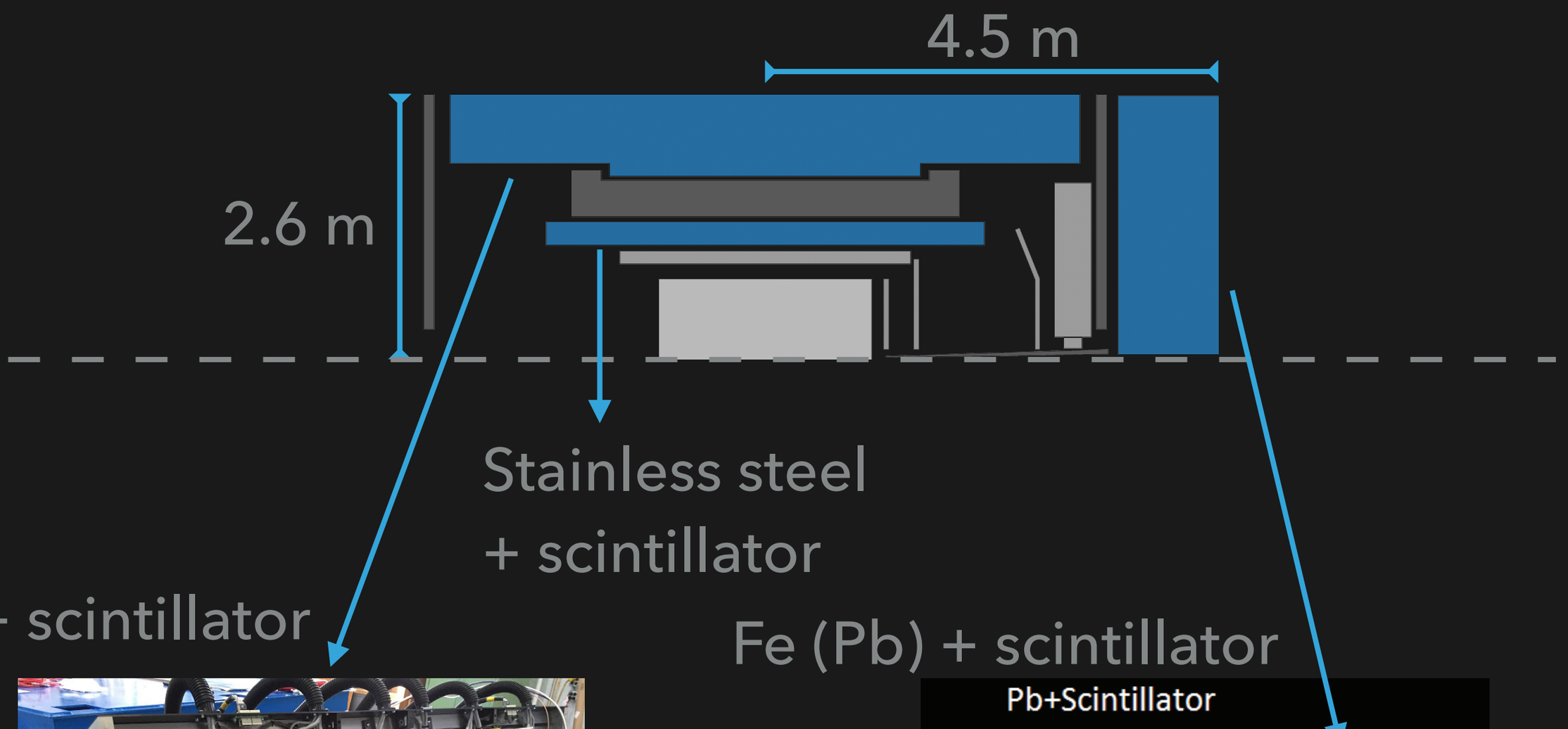


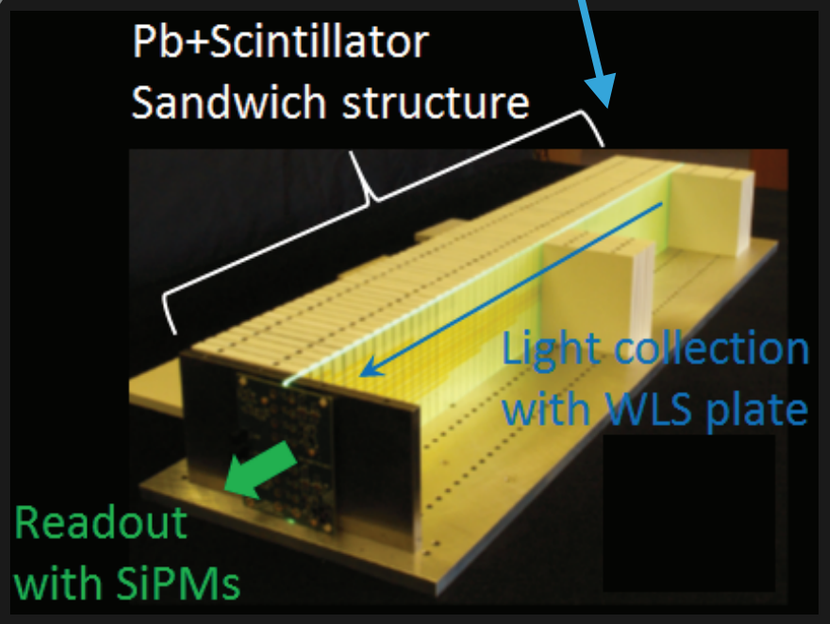
W + scintillating fibre

Pb + scintillator (PHENIX)

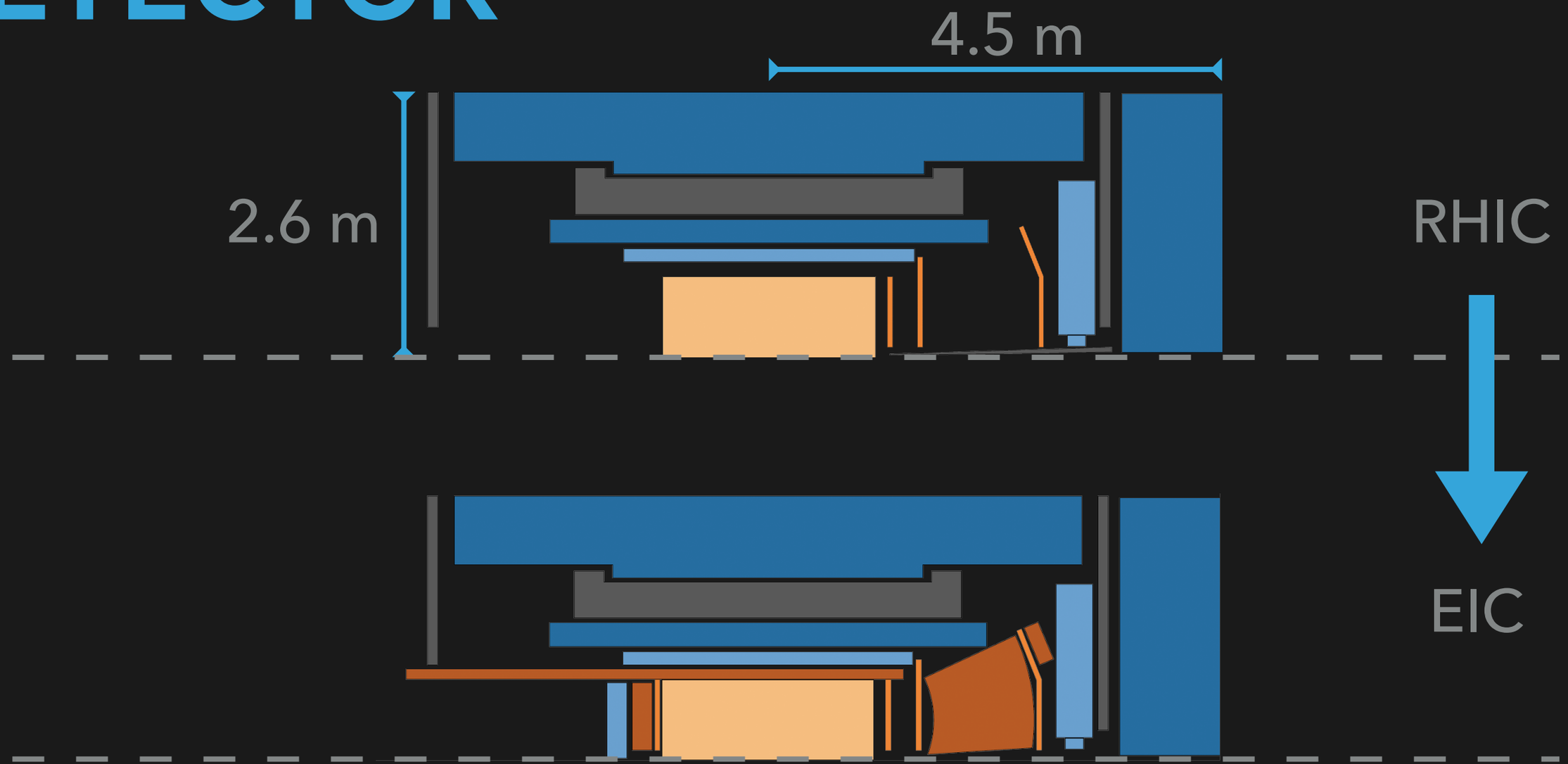
$PbWO_4$ crystal (PHENIX)

HADRON CALORIMETER





EVOLUTION INTO A DAY-1 EIC DETECTOR



NUCLEAR PARTON DISTRIBUTION FUNCTIONS

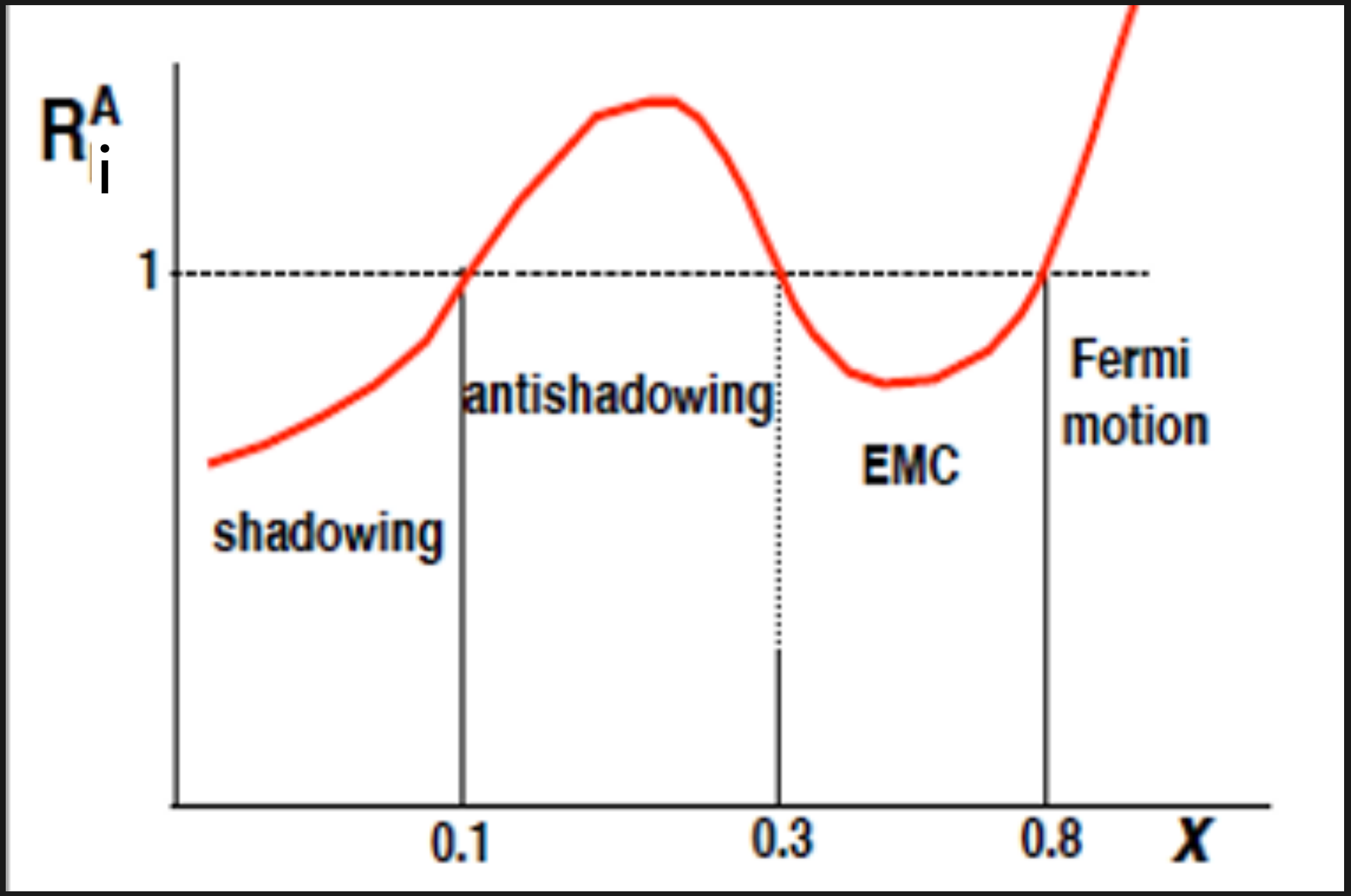
LUMINOSITY ASSUMPTIONS

	Recorded Lumi.	Sampled Lumi.
Au+Au 200 GeV	$35.0 nb^{-1}$	$80 nb^{-1}$
p↑+Au 200 GeV	-	$0.33 pb^{-1}$
p↑+p↑ 200 GeV	-	$197 pb^{-1}$
p↑+p↑ 510 GeV	-	$488 pb^{-1}$

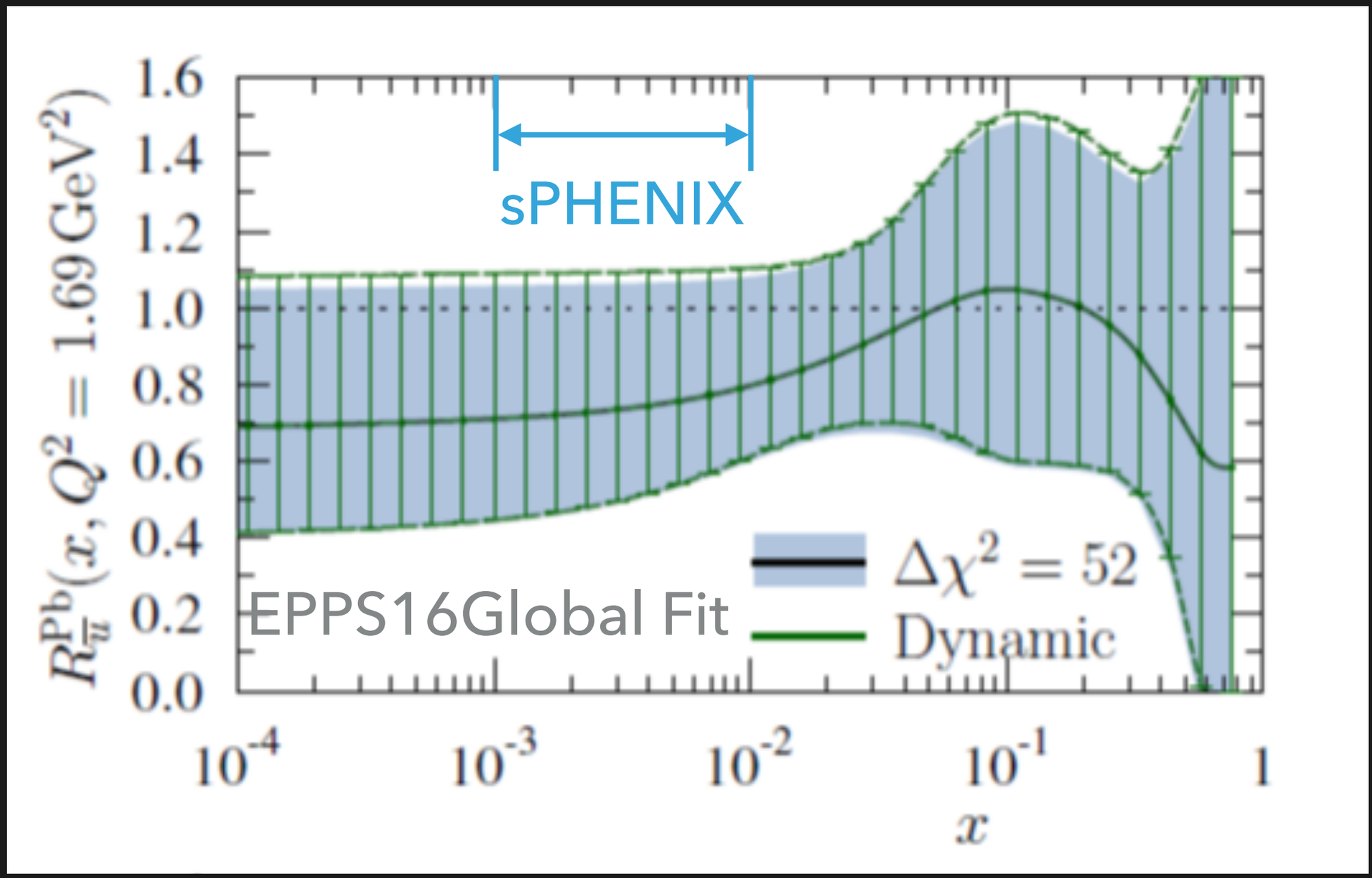
Possible 5-year sPHENIX run plan presented to BNL PAC 6/15/2017

HOW DOES THE NUCLEAR ENVIRONMENT AFFECT THE DISTRIBUTION OF QUARKS AND GLUONS AND THEIR INTERACTIONS IN NUCLEI?

NUCLEAR MODIFICATION OF PARTON DISTRIBUTIONS



GLOBAL FITS EXTRACT NUCLEAR MODIFICATION



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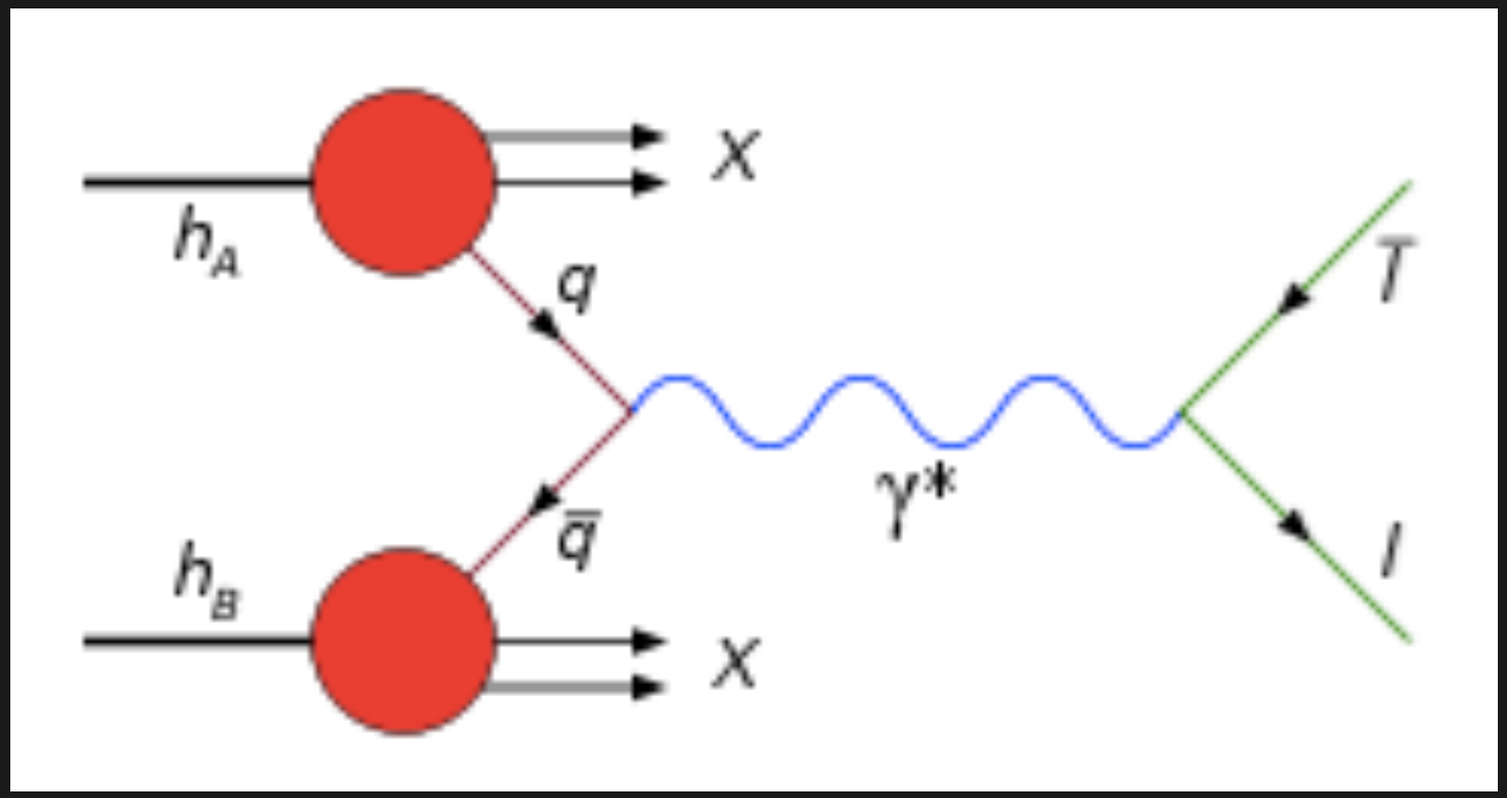
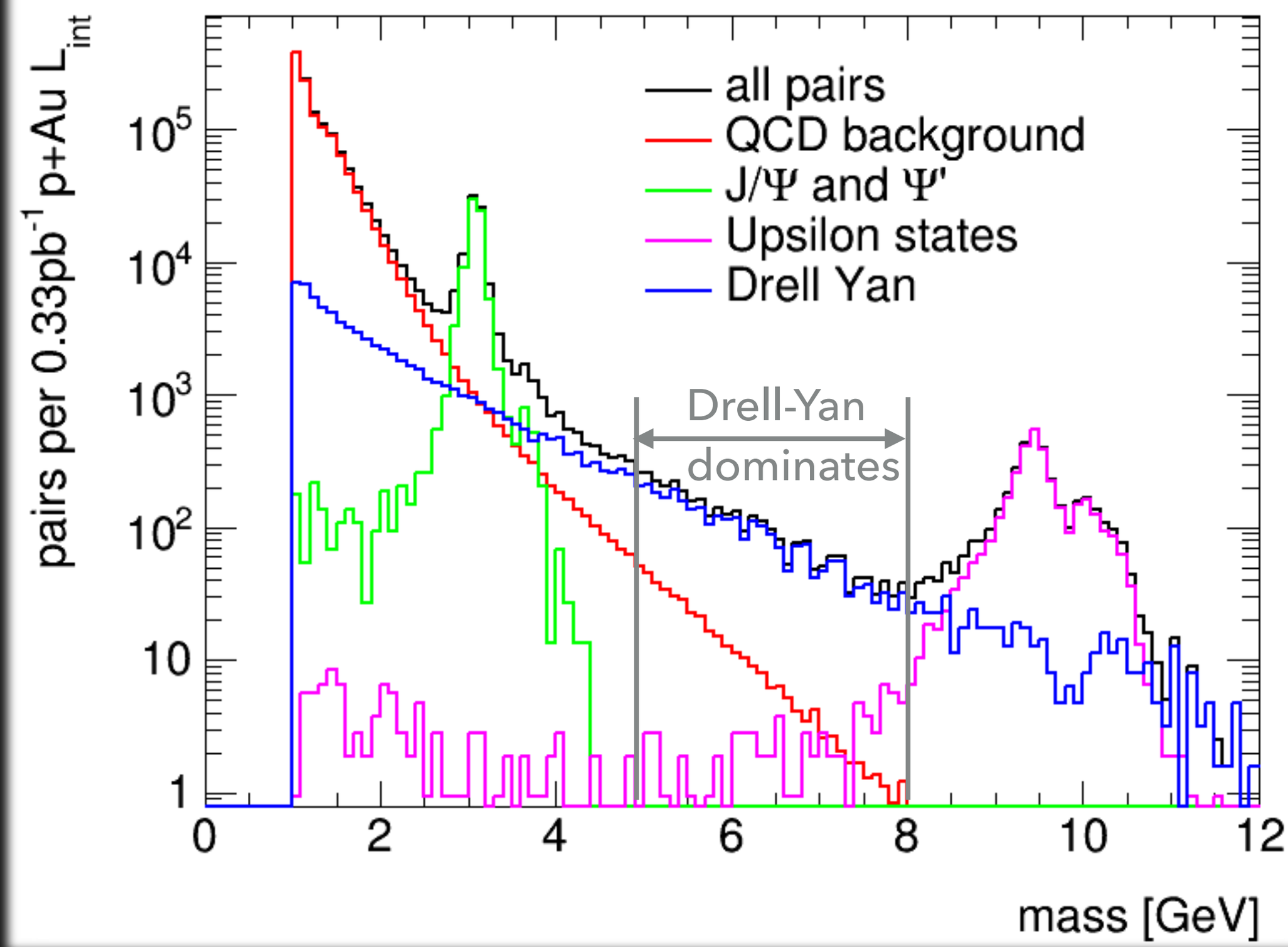
DRELL-YAN EVENTS PROBE SEA ANTIQUARKS IN NUCLEI



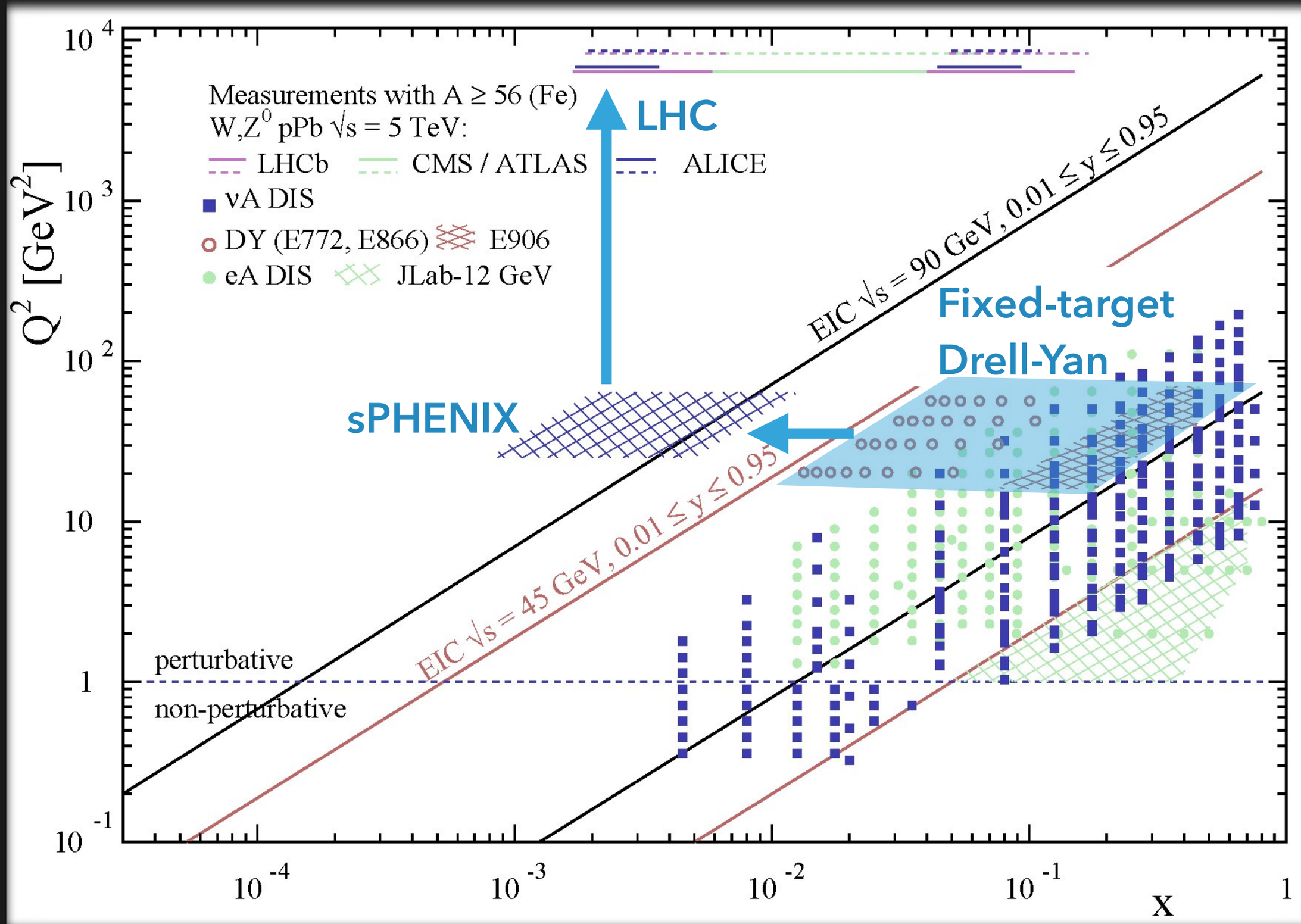
large x_A of quark inside proton

small x_B of anti-quark inside nucleus

HOW WELL CAN WE MEASURE DRELL-YAN EVENTS?

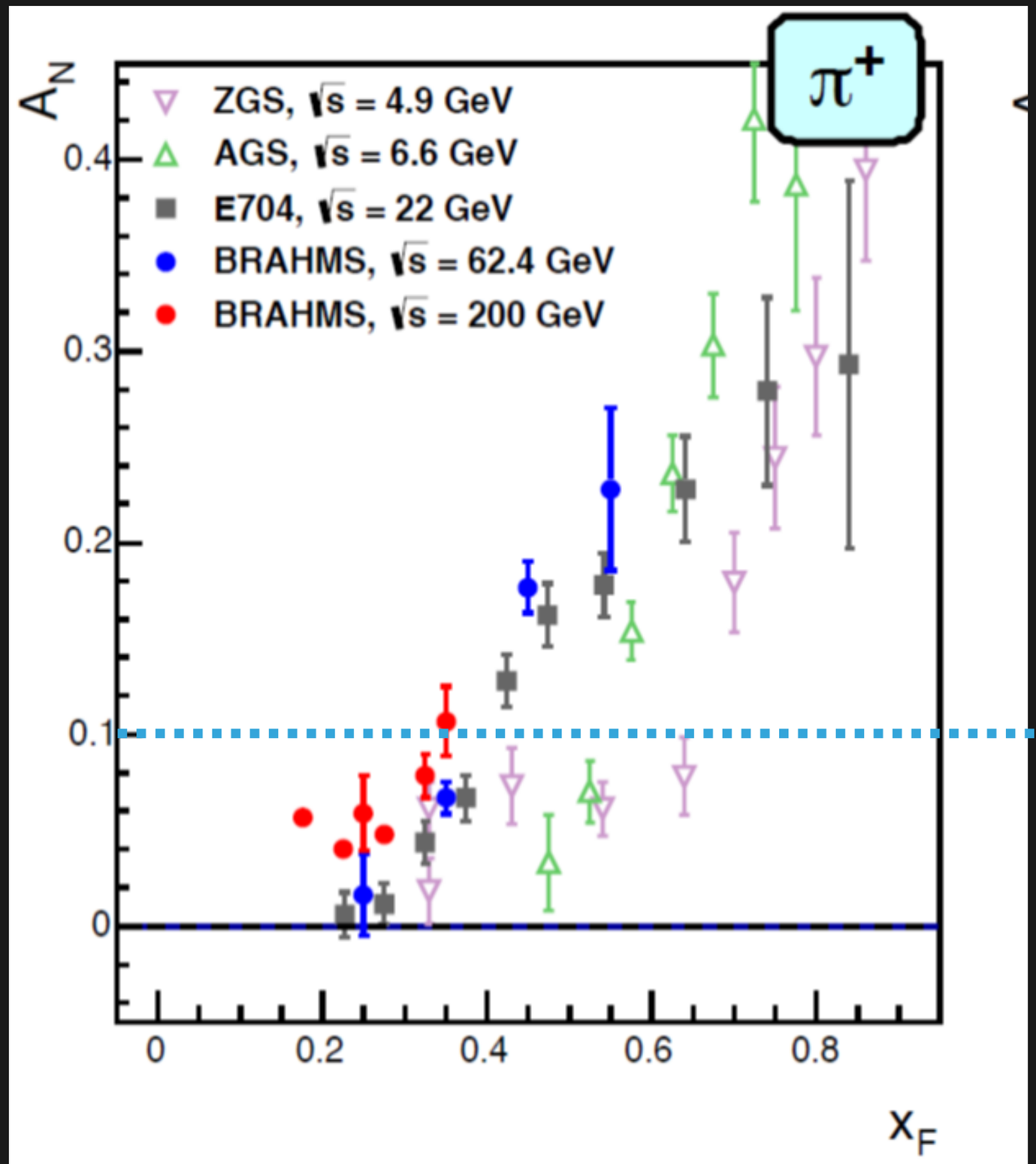


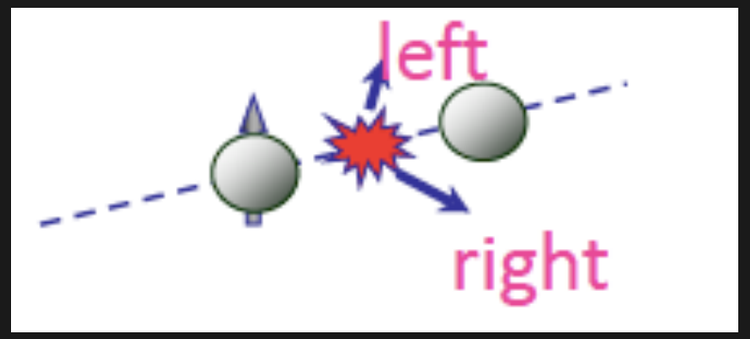
DATA COMPLEMENT LHC AND FIXED-TARGET EXPERIMENTS



TRANSVERSE SINGLE-SPIN ASYMMETRIES

LARGE SPIN-MOMENTUM CORRELATIONS IN TRANSVERSELY POLARIZED P+P COLLISIONS

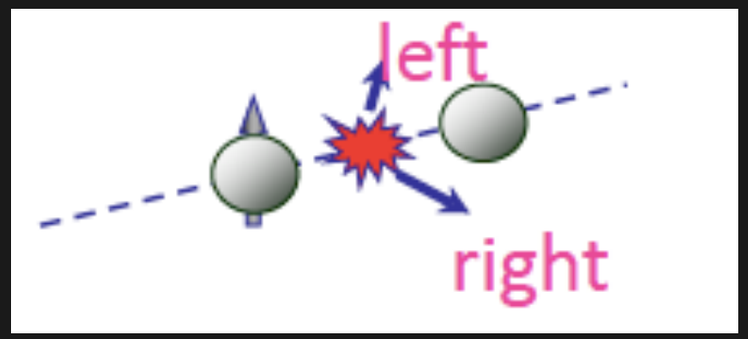


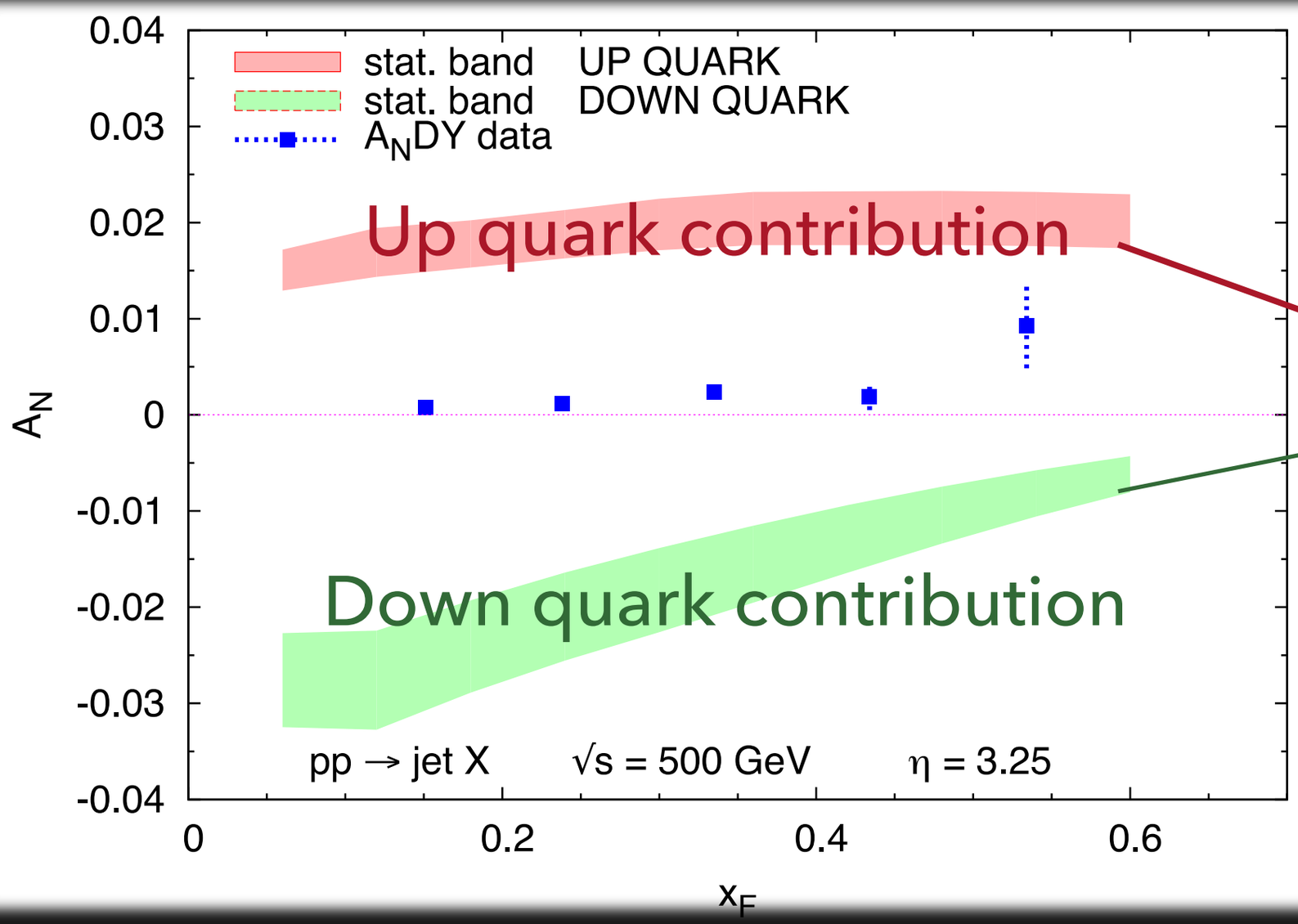


BUT:

Only 1-10% in SIDIS

WHY NOT FOR INCLUSIVE JET MEASUREMENTS?

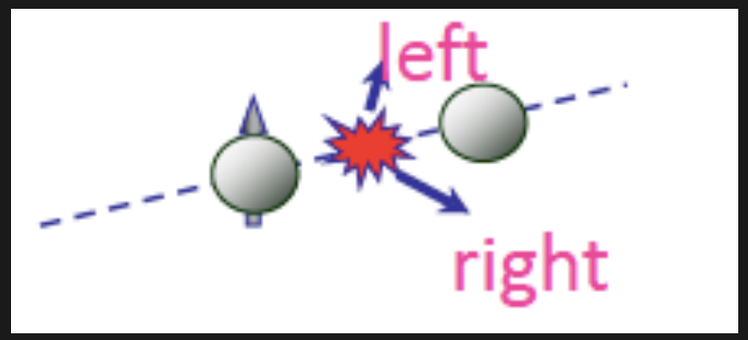


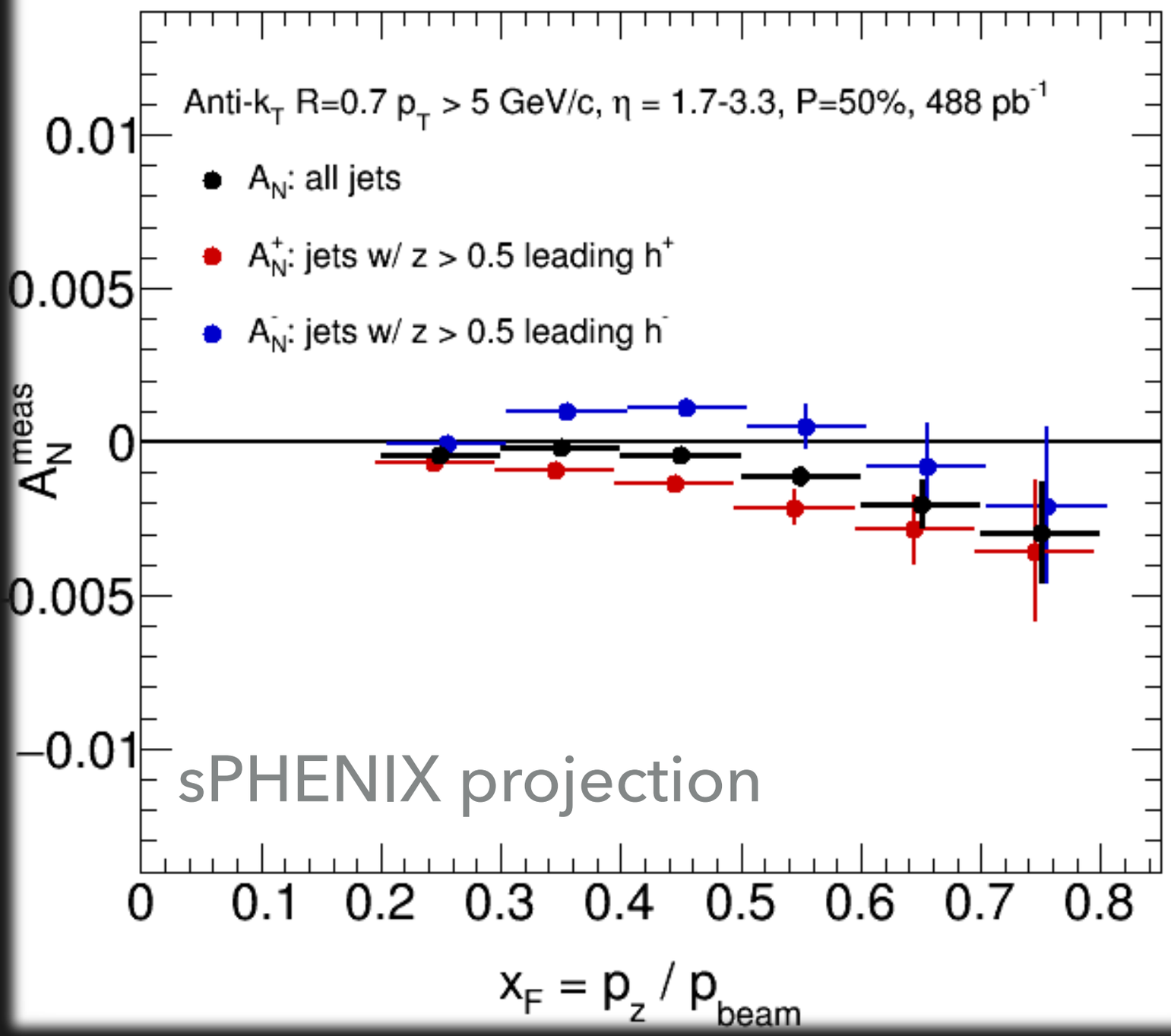


Cancellation?

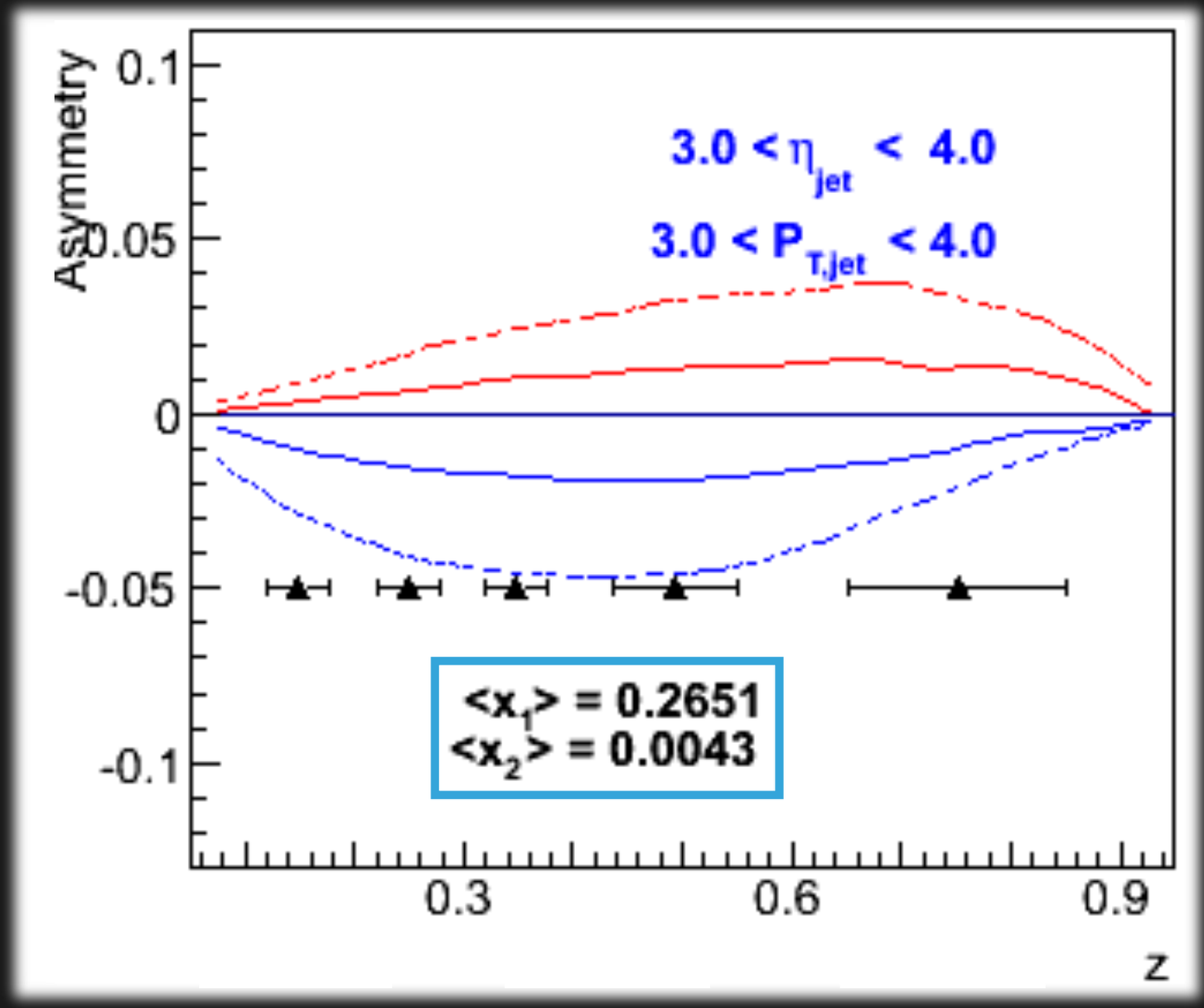
Comparison:
Up to 15% for π^0

SEPARATING UP- AND DOWN-QUARK JET CONTRIBUTIONS





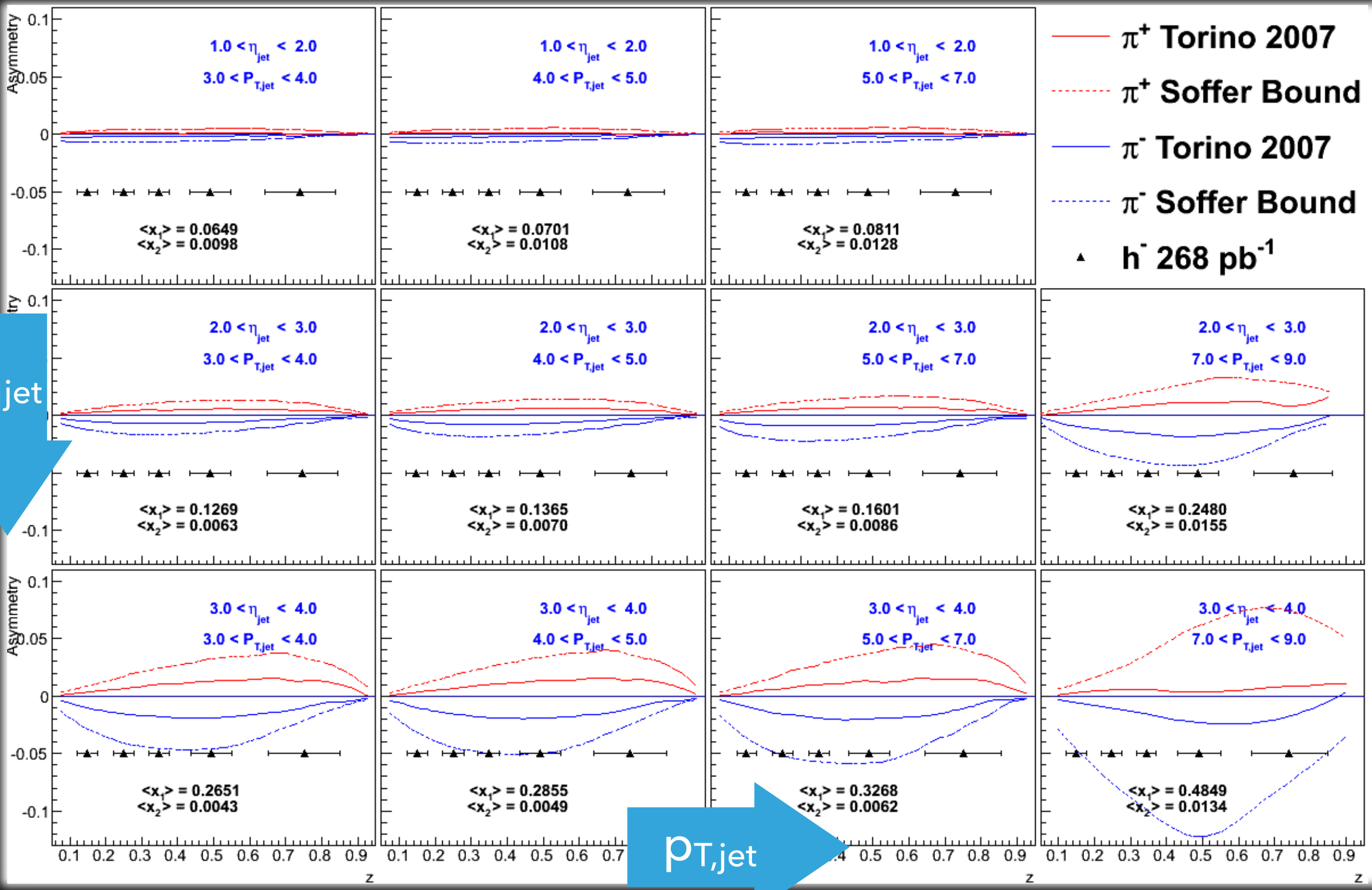
ACCESSING TRANSVERSITY VIA HADRONS WITHIN JETS



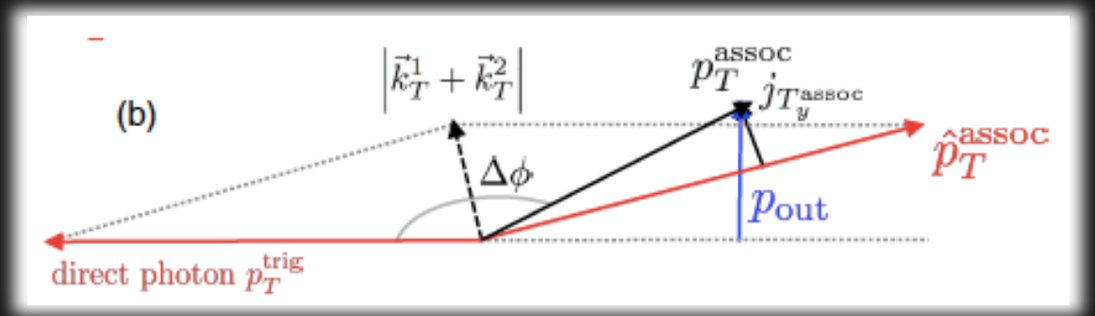
compare to SIDIS as function of x, z, and Q^2

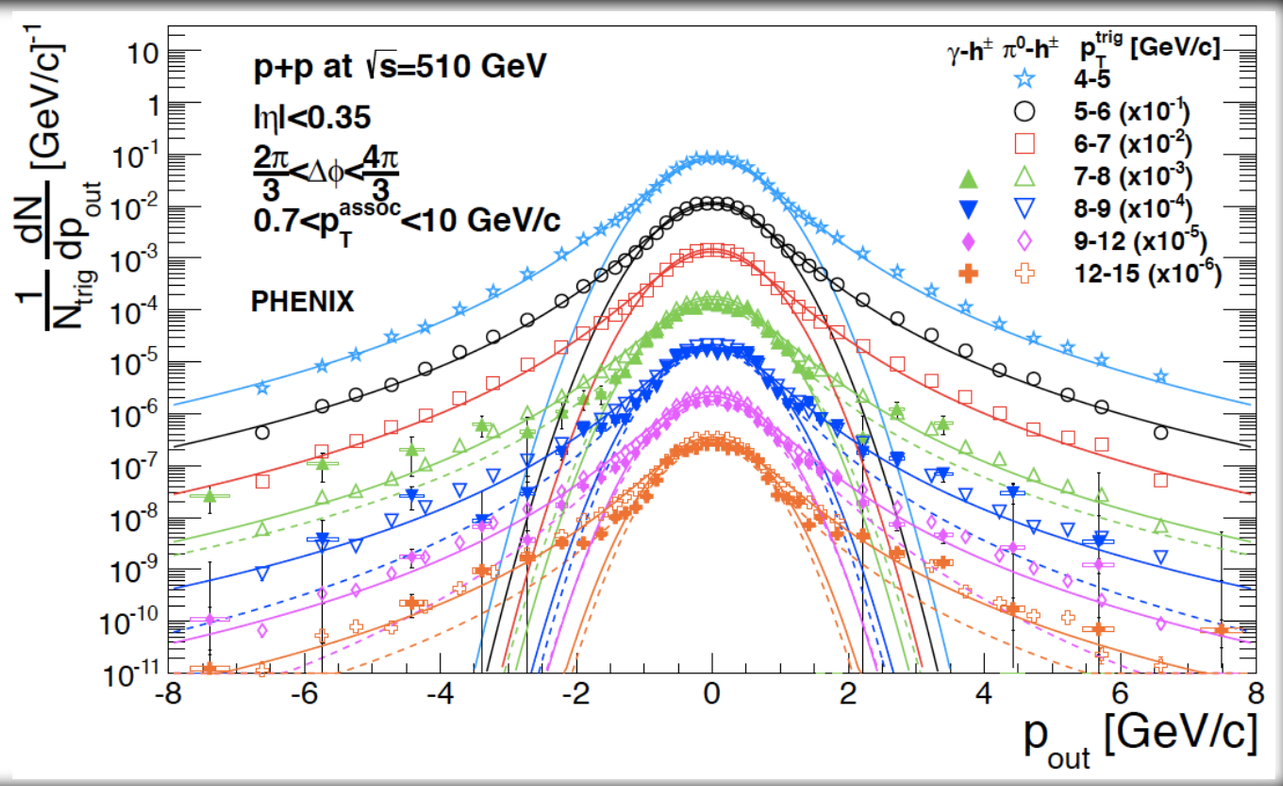
π^+ Torino 2007
π^+ Soffer Bound
π^- Torino 2007
π^- Soffer Bound
h^- 268 pb^{-1}

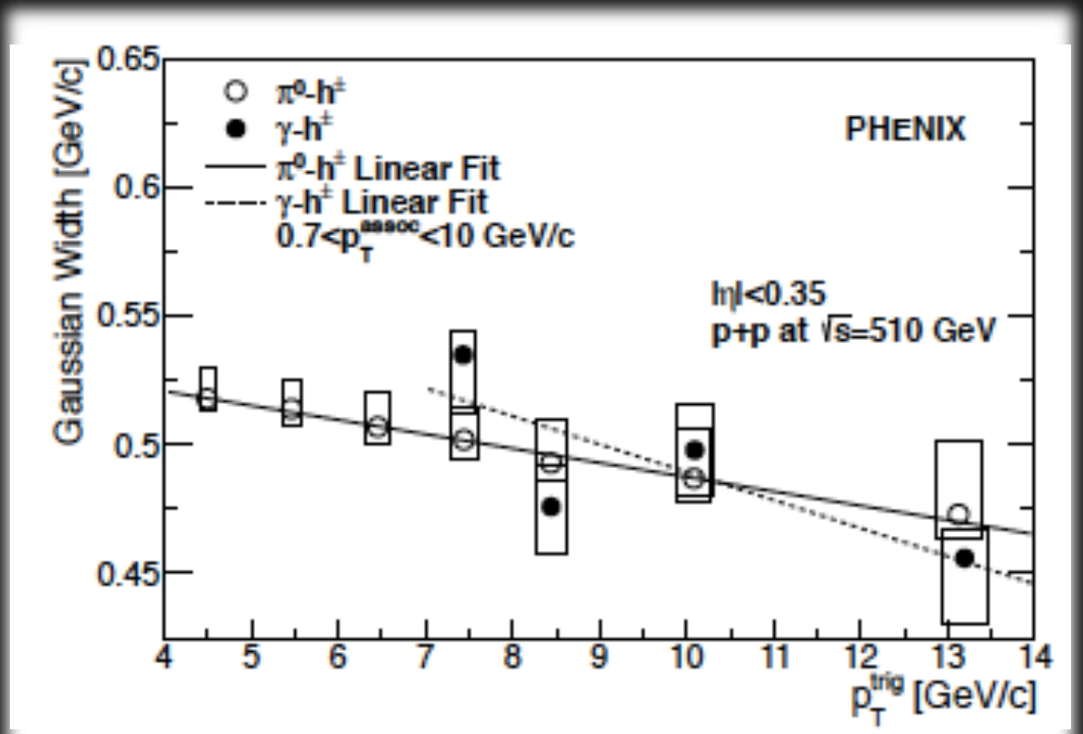
SPHENIX COVERS WIDE RANGE IN X UP TO X = 0.5



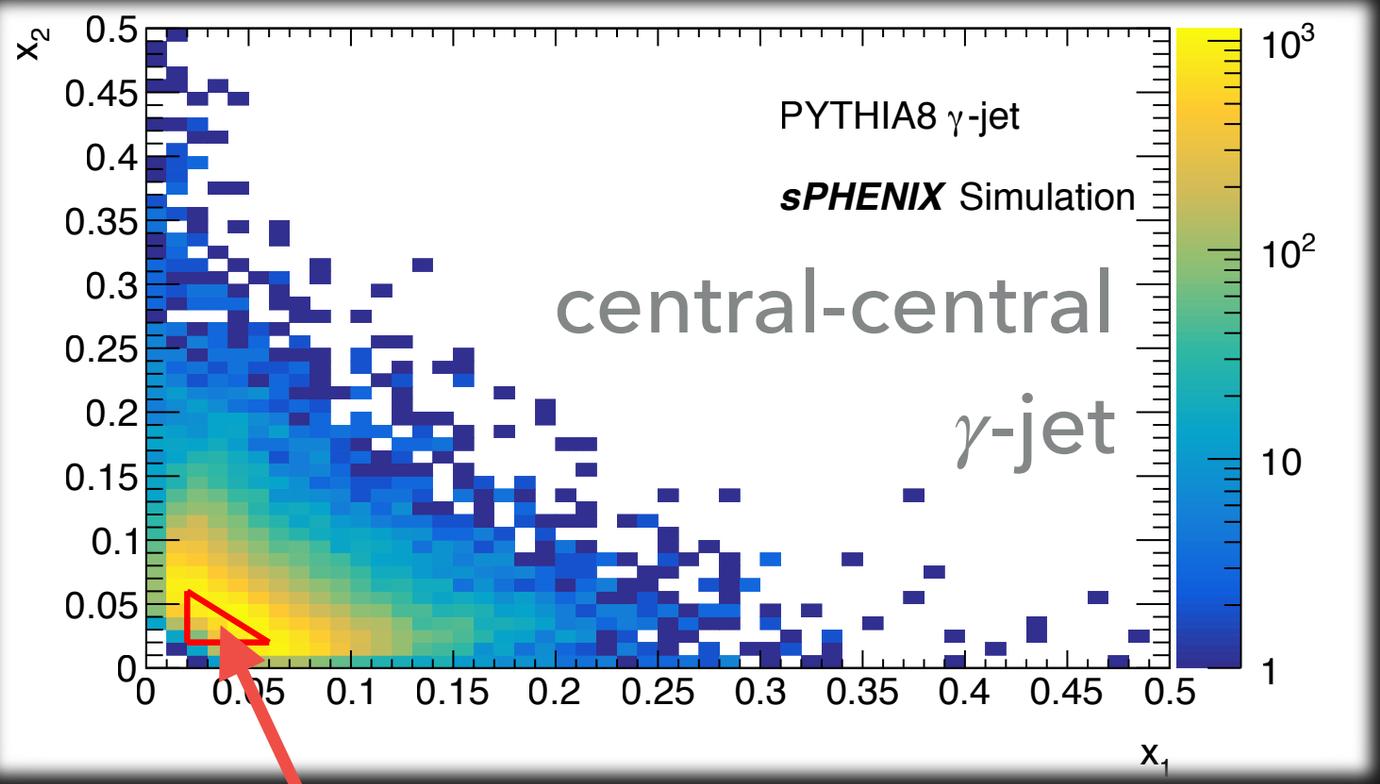
INVESTIGATING FACTORIZATION BREAKING IN PHENIX



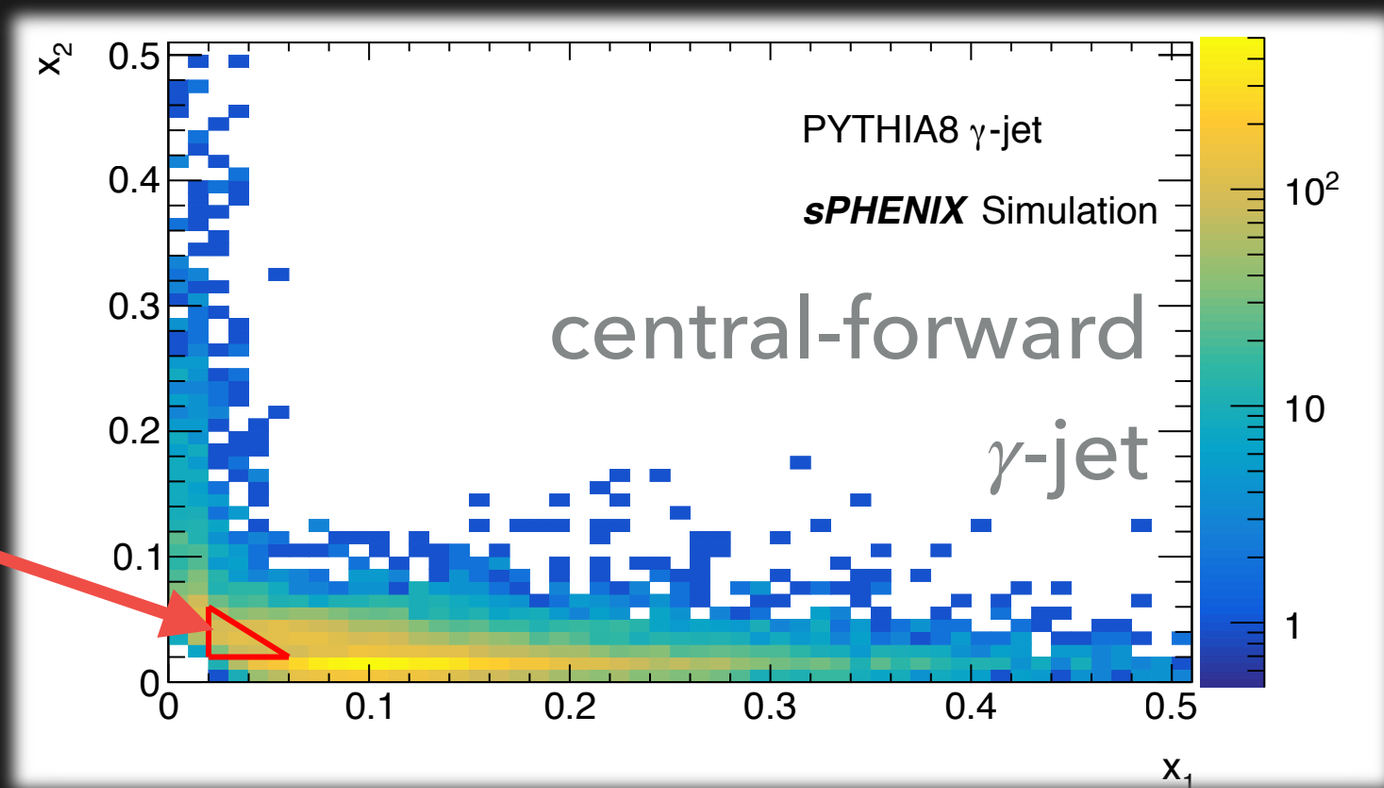




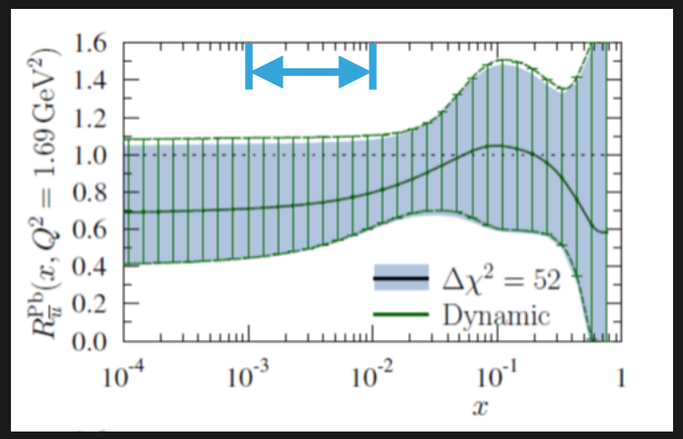
SEARCHING FOR NON-ABELIAN EFFECTS IN γ-JET AND DI-JET CORRELATIONS

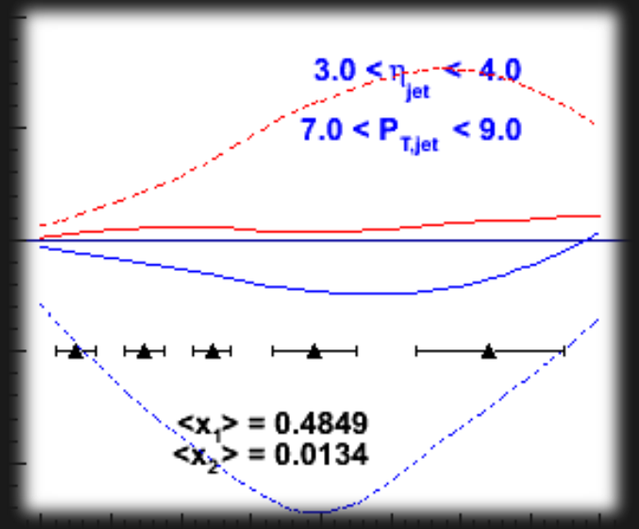


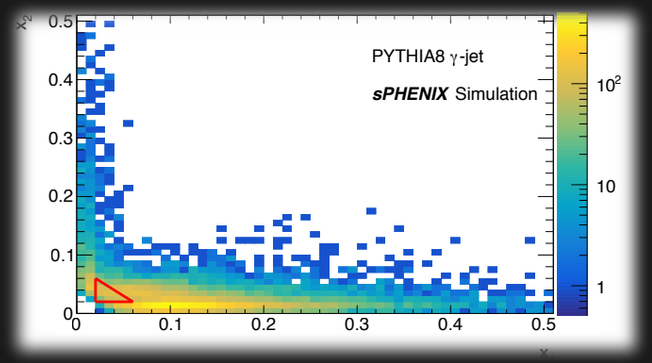
PHENIX midrapidity
γ-hadron correlations



SPHENIX CAN HELP UNLOCK THE FULL POTENTIAL OF AN EIC BY:







- constraining the nuclear anti-quark (and gluon) PDFs,
- measuring transverse single-spin asymmetries in hadronic collisions for tests of universality,
- directly exploring effects from factorization breaking in hadronic collisions.

REFERENCES

- An Upgrade Proposal from the PHENIX Collaboration (sPHENIX): arXiv:1501.06197v1 [nucl-ex]
- LOI for sPHENIX forward instrumentation: https://www.sphenix.bnl.gov/web/node/450
- RHIC Cold QCD Plan: arXiv:1602.03922v1 [nucl-ex]
- EPPS16: Nuclear parton distributions with LHC data: Eur.Phys.J. C77 (2017) no.3, 163 , DOI: 10.1140/epjc/s10052-017-4725-9
- Nonperturbative-transverse-momentum effects and evolution in dihadron and direct photon-hadron angular correlations in p+p collisions at sqrt{s}=510 GeV : Phys. Rev. D 95, 072002 (2017), DOI: 10.1103/PhysRevD.95.072002

Multi-year run plan scenario for sPHENIX

Year	Species	Energy [GeV]	Phys. Wks	Rec. Lum.	Samp. Lum.	Samp. Lum. All-Z
2022	Au+Au	200	16.0	7 nb^{-1}	8.7 nb^{-1}	34 nb^{-1}
2023	p+p	200	11.5	—	48 pb^{-1}	267 pb^{-1}
2023	p+Au	200	11.5	—	0.33 pb^{-1}	1.46 pb^{-1}
2024	Au+Au	200	23.5	14 nb^{-1}	26 nb^{-1}	88 nb^{-1}
2025	p+p	200	23.5	—	149 pb^{-1}	783 pb^{-1}
2026	Au+Au	200	23.5	14 nb^{-1}	48 nb^{-1}	92 nb^{-1}

- Guidance from ALD to think in terms of a multi-year run plan
- Consistent with language in DOE CD-0 “mission need” document
- Incorporates updated C-AD guidance now officially documented
- Run plan relates to capabilities of full barrel detector
- Incorporates commissioning time in first year

Minimum bias Au+Au at 15 kHz for |z| < 10 cm:
47 billion (2022) + **96 billion** (2024) + **96 billion** (2026) = Total **239 billion events**

For topics with Level-1 selective trigger (e.g. high p_T photons), one can sample within |z| < 10 cm a total of 550 billion events. One could consider sampling events over a wider z-vertex for calorimeter only measurements, 1.5 trillion events.

Presented by D. Morrison to BNL PAC 6/15/2017